Method of and an apparatus for displaying a picture

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Abstract

In a method of displaying a picture according to the present invention, at least one starting point is determined on a picture screen; a picture is produced on a spiral raster which diverges from or converges toward each of the starting points; a shape, phase, linear density, and scanning speed of each spiral raster are controlled; thereby the patterns displayed on the screen are moved, rotated, enlarged, reduced, or modified. The central position of this spiral raster is given by setting deflection control signals in the X and Y directions of an electron beam into fixed values. The spiral raster is given by adding sine waves whose amplitudes gradually increase or decrease to the above deflection control signals. When the frequencies of the deflection control signals are constant, the scanning is performed at a constant angular velocity. On the other hand, when the frequencies are changed in proportion to the amplitudes, the scanning can be done at a constant speed.

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(54) Method of and an apparatus for displaying a picture.

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The central position of this spiral raster is given by setting deflection control signals in the X and Y directions of an electron beam into fixed values. The spiral raster is given by adding sine waves whose amplitudes gradually increase or decrease to the above deflection control signals.

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METHOD OF AND AN APPARATUS FOR DISPLAYING A PICTURE

This invention relates to a method of and an apparatus for displaying a picture by scanning an electron beam along a spiral raster on a screen in the case where a picture is displayed by the steps of: scanning on the screen such as a cathode ray tube by the electron beam; changing intensity of the electron beam which changes the luminance of each light spot to be generated on the screen. More concretely, this invention relates to a method of producing a pattern on the screen of a video gaming machine and the like by the above-mentioned spiral raster scanning method and of very freely moving, rotating, modifying, enlarging or reducing that pattern at any time, and to an apparatus for embodying the method.

In video gaming machines, it is necessary to display many kinds of characters or patterns on a screen and to move, rotate, modify, enlarge or reduce these characters or patterns on the basis of a predetermined program and rule for a game, thereby to develop the required process of the game.

One well-known method of generating those patterns is to use parallel raster scanning method which is similar to the case of a

standard TV receiver, and the other one is a random scanning or vector generating method.

In the former method, each scan line is divided into a number of picture display elements and the luminance of each picture element is controlled; as a result, a picture is displayed as a mosaic pattern consisting of a series of picture elements along the scan line.

With this method, therefore, colorful patterns suitable for a gaming machine can be easily constituted since these patterns are displayed as a combination of various color images. However, in this method, although the generated patterns can be easily moved horizontally and vertically on the screen, there is the problem that a high-speed processing unit and a relatively large capacity memory are needed to rotate, enlarge or reduce these patterns.

Even in the case of an extremely simple pattern, e.g. a square and the like, if one desires to smoothly rotate this pattern, a processing unit which is too advanced and expensive to be used in a gaming machine because price limitations is required. In other words, it is impossible to smoothly perform the rotation, enlargement, reduction, etc. of a complicated pattern at a high speed by a cheap processing circuit which can be adopted for a raster scan gaming machine; therefore, there is a problem that, for example, the rotational movement has to be represented by an approximate rotational movement based on the discontinuous rotational indication such that the pattern jumps and is displayed at intervals of, say, 30 degrees of rotational angle or the like.

In the latter random scanning method, the X-Y deflection angles of the electron beam are controlled without using any raster, thereby drawing a line image on the screen.

With this method, since a pattern is displayed as an aggregate of a relatively small number of straight lines, i.e. vectors to be displayed on the screen, little computational effort is necessary to rotate, enlarge and reduce the pattern. Thus, the pattern can be smoothly rotated, enlarged and reduced at high speed even by a low-speed processing unit of small capacity. However, displayed patterns are limited to simple line drawings consisting of a relatively small number of straight lines or to a hollow outline drawing without any filled-in color areas; therefore, there is a problem that the displayed pattern lacks substance and brilliance and that this may diminish interest in the game.

It is an object of the present invention, therefore, to provide a novel method of and an apparatus for displaying a picture whereby a substantial brilliant picture similar to the raster scanning method can be freely moved, rotated, enlarged, and reduced using a processing circuit of a scale of complexity and cost which is almost equal to that in the random scanning method.

The gist of the present invention is that: at least one starting point is determined on the screen; pictures are produced on spiral rasters which diverge from each of the above-mentioned starting points or which converge to each of the starting points; the shapes, phases,

linear densities, and scanning speeds of each of those spiral rasters are controlled; thereby the patterns displayed on the screen are moved, rotated, enlarged, reduced or modified.

The central position of this spiral raster is given by setting deflection control signals in the X and Y directions of the electron beam into fixed values. The spiral raster is produced by adding a sine wave whose amplitude gradually increases or decreases to the above-mentioned deflection control signals.

Assuming that the frequencies of the deflection control signals are constant, the scanning operation is performed at a constant angular velocity. On the other hand, if the frequencies are changed in proportion to the amplitudes, the scanning operation can be done at a constant velocity.

In a preferred embodiment of the present invention, the spiral raster is divided into a number of segments and a peculiar address and a luminance data corresponding to its address are given to each segment respectively, thereby forming a video signal to control an intensity of the electron beam and controlling the intensity of the electron beam for every segment synchronously with the scanning operation, and as a result of it, the luminance of the above segment is controlled and a pattern is displayed.

Although there is well known a spiral raster scanning TV in which a screen of the cathode ray tube is spirally scanned and a

picture is generated on the screen by its electron beam, it is not yet put to practical use.

In a known spiral raster scanning TV, the picture is scanned along a circular or elliptical spiral which diverges outwardly from the central point of the CRT screen or which converges inwardly toward the central point of the screen from the outside, thereby forming a picture on the whole screen or its central portion which is similar to the picture that will be displayed by an ordinary parallel line raster scanning method. On the contrary, a technology is not yet known whereby particular patterns or characters can be generated in required positions at any time and their movement, rotation, etc. are performed by controlling the phase or the like of the sine wave signal for deflecting the electron beam.

In the polar coordinate system(r, θ), such a spiral raster as described above is represented by following expression (1)

$$r = C(\theta - \beta) \qquad \ldots\ldots\ldots\ldots (1)$$

wherein C and β are constants.

When it is assumed that $\beta = 0$ in expression (1), and r, θ and C are replaced as

$$r = R_0 \cdot t$$
$$\theta = \omega_0 \cdot t \qquad \ldots\ldots\ldots\ldots (2)$$
$$C = \frac{R_0}{\omega_0}$$

wherein R_0 and ω_0 are constants and t is a time;

the scanning operation is performed at an equiangular velocity.

In addition, when a linear velocity is V and assuming that

$$V = \sqrt{\left(\frac{dr}{dt}\right)^2 + \left(r\frac{d\theta}{dt}\right)^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

is constant, the scanning operation is done at a constant speed.

Expression (3) can be also written like following expression (4).

$$V = \frac{1}{C}\sqrt{C^2 + r^2}\;\frac{dr}{dt}$$

$$Vt = \int_0^t V\,dt = \int_0^r \frac{1}{C}\sqrt{C^2 + r^2}\,dr$$

$$= \frac{1}{2C}\left[r\sqrt{C^2 + r^2} + C^2 \cdot \log\left(r + \sqrt{C^2 + r^2}\right)\right]_0^r$$

$$= \frac{1}{2C}\left(r\sqrt{C^2 + r^2} + C^2 \cdot \log\frac{r + \sqrt{C^2 + r^2}}{C}\right) \quad \ldots\ldots\ldots\ldots \quad (4)$$

It can be understood from expressions (1)and (4) that the scanning operation at a constant velocity is performed.

These scanning operations can be realized when signals X(t) and Y(t) for deflecting the electron beam in the X and Y directions are represented by following expression (5) or (6)

$$X(t) = X_0 + F_1(t) \cdot \sin[\omega_1(t) \cdot t + \beta_1]$$
$$Y(t) = Y_0 + F_2(t) \cdot \sin[\omega_2(t) \cdot t + \beta_2] \quad \ldots\ldots\ldots\ldots \quad (5)$$

$$X(t) = Y_0 + F_2(t) \cdot \sin[\omega_1(t) \cdot (t_0 - t) + \beta_1]$$
$$Y(t) = Y_0 + F_2(t) \cdot \sin[\omega_2(t) \cdot (t_0 - t) + \beta_2] \quad \ldots\ldots\ldots\ldots \quad (6)$$

wherein X_0, Y_0, β_1, and β_2 are constants, t is a time ($0 \leq t \leq t_0$), and $F_1(t)$, $F_2(t)$ $\omega_1(t)$, and $\omega_2(t)$ are functions with respect to the time.

The figures to be produced on the basis of the above-mentioned expressions (5) and (6) are generally the Lissajous' figures which complicatedly changed as the time passes. However, only the simplest circular spiral raster will be dealt with hereinafter.

That is to say, it is now assumed that

$$\beta_1 = \beta_2 + \frac{\pi}{2}$$

$$\beta_2 = \beta$$

$$F_1\ (t) = F_2\ (t) = F(t)$$

$$\omega_1\ (t) = \omega_2\ (t) = \omega(t)$$

Furthermore, when F(t) is a monotonic increasing function and (t) is a constant, expression (5) provides a spiral raster which diverges from the point (X_0, Y_0) and expression (6) provides a spiral raster which converges to the point (X_0, Y_0).

The point (X_0, Y_0) is the central point of the spiral raster and the spiral raster together with the pattern can be in parallel motion by sequentially changing the values of these X_0 and Y_0. The pattern can be rotated around the central point of the spiral raster by changing the phase difference of the sine wave signal portion. The raster can be modified from circle to ellipse and further to a linear shape, and vice versa by changing the phase difference(β_1 – β_2). Furthermore, the pattern displayed can be enlarged, reduced, or modified by controlling the amplitudes $F_1(t)$ and $F_2(t)$.

The spiral raster which can be used in the present invention is not limited only to the spirals shown by the above-mentioned expressions. However, of course, it may be possible to use and

pseudo-spiral which is constituted by combining circular arcs as will be described later, - shaped or elliptic spiral, and other more complicated spirals whose interlinear distances or the like are not constant.

The objects and constitutions of the present invention described above will become more apparent from the following detailed description referring to the accompanying drawings.

Figs.1 and 2 are plane views showing examples of spiral rasters to be produced from the above-mentioned expression (5) or (6);

Figs. 3 and 4 are plane views showing examples of pseudo-spiral rasters consisting of circular arcs; and

Fig. 5 is a circuit diagram showing one embodiment of a picture displaying apparatus according to the present invention.

The circular spiral rasters shown in Figs. 1 and 2 are obtained as follows.

That is, in expression (5), assuming that

$$F_1(t) = F_2(t) = F_0(t)$$

$$\omega_1(t) = \omega_2(t) = \omega_0 = \text{constant}$$

$$\beta_1 = \beta_2 + \frac{\pi}{2}$$

$$\beta_2 = \beta$$

expression (5) will be

$$X(t) = X_0 + F_0 \cdot t \cdot \cos[\omega_0 \cdot t + \beta]$$
$$Y(t) = Y_0 + F_0 \cdot t \cdot \sin[\omega_0 \cdot t + \beta] \qquad \ldots\ldots (7)$$

Expressions (7) represent a circular vibration in which the radius increases in proportion to the time and they represent the spiral raster which diverges from the point (X_0, Y_0). $2\pi F_0/\omega_0$ is an interlinear distance and β is a parameter indicative of its phase.

When $\beta = 0$, the spiral raster is as shown in Fig. 1 and when $\beta \neq 0$, it is as shown in Fig. 2.

Now, assuming that

$$\beta = \beta(t)$$
$$= \Omega \cdot t$$
$$\Omega = \text{constant} > 0$$

the spiral raster rotates in the positive direction (counterclockwise in the drawings) at a constant angular velocity Ω.

Although a similar spiral raster is obtained from expression (6), in this case, the point $[X(t), Y(t)]$ centripetally moves toward the point (X_0, Y_0).

On the other hand, the spiral rasters consisting of the combinations of circular arcs which are shown in Figs. 3 and 4 are obtained as follows.

In expression (5), assuming that

$$F_1(t) = F_2(t)$$

$$= F_0$$

$$\omega_1 (t) = \omega_2 (t)$$

$$= \omega_0$$

$$= \text{constant}$$

$$\beta_1 = \frac{\pi}{2}$$

$$\beta_2 = 0$$

$$X_0 = X_0 + x_0$$

then we obtain

$$X (t) = X_0 + x_0 + F_0 \cdot \cos[\omega_0 \cdot t]$$

$$Y (t) = Y_0 + F_0 \cdot \sin[\omega_0 \cdot t] \qquad \cdots\cdots\cdot (8)$$

These are equations of circular vibration around the point $(X_0 + x_0, Y_0)$.

It is now assumed that

$\frac{\pi}{\omega_0} = T$ and

when $t = 0$;	assumed that	$F_0 = 0$
when $0T < t \leqq 1T$;		$F_0 = 1 \cdot \Delta F$
when $1T < t \leqq 2T$;		$F_0 = 2 \cdot \Delta F$
when $2T < t \leqq 3T$;		$F_0 = 3 \cdot \Delta F$
when $3T < t \leqq 4T$;		$F_0 = 4 \cdot \Delta F$
....		....
when $(n-1)T < t \leqq nT$;		$F_0 = n \cdot \Delta F$
....		....
when $(N-1)T < t \leqq NT = t_0$;		$F_0 = N \cdot \Delta F$ $= D$.

and also when $n = 0$; assumed that $x_0 = 0$

when n is an odd number; $x_0 = 0$

when n is an even number; $x_0 = -\frac{\Delta F}{2}$

As a result of this, the spiral raster shown in Fig.3 is obtained.

This spiral raster consists of semicircular arcs of which the radius increases up to F at every semicircle. In Fig. 3, the center of the semicircular arc in the area of

$$Y' = Y - Y_0 > 0$$

locates at (X_0, Y_0), and the center of the semicircular arc in the area of

$$Y' = Y - Y_0 < 0$$

locates at $(X_0 - \frac{\Delta F}{2}, Y_0)$.

This spiral is such that the interlinear distance is Δ F and the angular velocity for the central point of the point $[X(t), Y(t)]$ which moves along the spiral raster is a constant value ω_0 and that the speed at which that point leaves from the central point is $\frac{\Delta F \cdot \omega_0}{2\pi}$.

This spiral raster moves in association with continuous changes of X_0 and Y_0 in the above expressions as functions of the time substantially similar to that shown in Figs. 1 and 2.

In addition, although $\beta = 0$ in Fig. 3, this β is a constant to determine the phase of the spiral raster. For example, in place of expression (8), assuming that

$$X(t) = X_0 + x_0 + F_0 \cdot \cos[\omega_0 \cdot t + \beta]$$
$$Y(t) = Y_0 + F_0 \cdot \sin[\omega_0 \cdot t + \beta] \qquad \text{.........(9)}$$

as shown in Fig. 4, the spiral raster which is rotated by the angle β against the spiral raster shown in Fig. 3 is obtained.

Therefore, even in this case, when

$$\begin{aligned} \beta &= \beta(t) \\ &= \Omega \cdot t \\ &= \text{constant} > 0 \end{aligned}$$

the spiral raster rotates in the positive direction (counterclockwise in Fig. 4) at a constant angular velocity Ω.

In the above expression, ΔF is a constant to determine not only an interlinear distance but also a divergent rate of the spiral raster and a maximum diameter at $t = t_0$.

However, as described above, since the angular velocity of the scanning is constant under the condition of

$$\omega_1(t) = \omega_2(t) = \text{constant},$$

the moving speed of the luminescent spot on the CRT becomes faster in proportion to the distance from the point (X_0, Y_0), so that a problem occurs in that when a large pattern is drawn, the brightness at the peripheral portion reduces. To solve this problem, although it is a possible method to increase an intensity of the electron beam synchronously with the scanning, it may be also possible to set the moving speed of the luminescent spot itself to be constant as will be described hereinbelow.

Namely, assuming that

$$\begin{aligned} \omega_1(t) &= \omega_2(t) \\ &= \omega(t) \end{aligned}$$

and further when $\omega(t)$ is

$$\sqrt{\left[X(t) - (X_0 + x_0)\right]^2 + \left[Y(t) - Y_0\right]^2} \cdot \omega(t)$$

$$= V$$

$$= \text{constant}$$

the point $[X(t), Y(t)]$ can be moved at a constant tangential velocity.

That is to say,

when $t = 0$; assumed that $\omega(t) = 0$ and $F_0 = 0$

when $0 < \omega(t) \cdot t \leqq 1$; $\omega(t) = \frac{V}{1 \cdot \Delta F}$ and $F_0 = 1 \cdot \Delta F$

when $1\pi < \omega(t) \cdot t \leqq 2$; $\omega(t) = \frac{V}{2 \cdot \Delta F}$ and $F_0 = 2 \cdot \Delta F$

when $2\pi < \omega(t) \cdot t \leqq 3$; $\omega(t) = \frac{V}{3 \cdot \Delta F}$ and $F_0 = 3 \cdot \Delta F$

when $3\pi < \omega(t) \cdot t \leqq 4$; $\omega(t) = \frac{V}{4 \cdot \Delta F}$ and $F_0 = 4 \cdot \Delta F$

when $4\pi < \omega(t) \cdot t \leqq 5$; $\omega(t) = \frac{V}{5 \cdot \Delta F}$ and $F_0 = 5 \cdot \Delta F$

....

when $(n - 1)\pi < \omega(t) \cdot t \leqq n\pi$; $\omega(t) = \frac{V}{n \cdot \Delta F}$ and $F_0 = n \cdot \Delta F$

....

when $(N - 1)\pi < \omega(t) \cdot t \leqq N\pi$; $\omega(t) = \frac{V}{N \cdot \Delta F}$ and $F_0 = N \cdot \Delta F$

and when $n = 0$; assumed that $x_0 = 0$

when n is an odd number; $x_0 = 0$

when n is an even number; $x_0 = -\frac{\Delta F}{2}$,

the spiral raster of the constant linear velocity type of which the point $[X(t), Y(t)]$ moves at a constant tangential velocity V is obtained.

Furthermore, in expression (5), when

$$\beta_1 = \beta_2 = 0$$

the linear vibration is obtained. Therefore, by changing X_0 and/or Y_0, the partial parallel line raster can be obtained.

Although this is not a spiral raster, this raster can be generated by the apparatus of the present invention and it has an effect similar to that of the present invention.

As described in the above, according to a method of the present invention, it will be appreciated that electron beam deflection signals in the X and Y directions are given by the sine waves of which the amplitudes and/or cycles fluctuate.

Such a sine wave signal method not only causes a saw tooth wave generator and a synchronizing signal which are indispensable for an ordinary parallel line raster to become unnecessary but also allows the electron beam to be easily deflected.

Such a sine signal wave of which the amplitude and/or cycle fluctuates can be also easily obtained by an analog technique such as an amplitude modulation, frequency modulation, or the like or by a hybrid technique such as pulse width modulation or the like from an ordinary sine wave or square wave pulse train. A most desirable method, however, is that a desired criterion function X(t) is coded and is recorded in an ROM and this is read out if necessary, then a desired processing is performed to this, thereby obtaining a necessary control signal.

As these criterion functions X(t) and Y(t), they are determined such that, for example,

$X_1(t) = \cos t$

$Y_1(t) = \sin t$

$$X_2(t) = Y_2(t) = t$$
$$X(t) = X_1(t) \cdot X_2(t)$$
$$Y(t) = Y_1(t) \cdot Y_2(t)$$

When this is further coded, the recording is performed, for example, using numerals of $X_1(t)$, $X_2(t)$, $Y_1(t)$, and $Y_2(t)$ corresponding to

$$t = n \cdot \Delta t$$

(wherein n is an integer) as data, and the above-mentioned n corresponding to this data is recorded as an address.

The above-mentioned expressions can be rewritten as follows.

$$X_1(t) = \cos[n \cdot \Delta t]$$
$$Y_1(t) = \sin[n \cdot \Delta t]$$
$$X_2(t) = Y_2(t) = n \cdot \Delta t$$
$$X(t) = X_1(t) \cdot X_2(t) = x_1(n) \cdot x_2(n)$$
$$Y(t) = Y_1(t) \cdot Y_2(t) = y_1(n) \cdot y_2(n)$$

The spiral raster positioned in the standard location shown in Fig. 1 is readily obtained by the above expressions. On the other hand, in order to generate the spiral raster in the rotated location as shown in Fig. 2, it may be assumed that

$$X_1(t) = \cos[n_1 \cdot \Delta t]$$
$$Y_1(t) = \sin[n_1 \cdot \Delta t]$$
$$X_2(t) = Y_2(t) = n_2 \cdot \Delta t$$
$$n_1 \neq n_2$$

and that

$$X(t) = X_1(t) \cdot X_2(t)$$
$$Y(t) = Y_1(t) \cdot Y_2(t)$$

It will be easily understood that the value of $(n_1 - n_2)$ determines β.

In this method, the spiral raster is divided by the equiangle from the central point, so that the picture displaying elements on the spiral raster consist of microcircular arcs each having a constant central angle. Although this method is suitable for representation of the radial pattern, it is not always optimum for the representation of a pattern whose outline is constituted by the horizontal lines and vertical lines.

This method can be improved by a technique in that the spiral raster is divided into circular arcs each having a constant length or the outside of the spiral raster is divided more minutely by smaller dividing angle or the like.

However, as a better method, such a method as shown in Figs. 3 and 4 is recommended whereby the spiral raster is divided like a lattice by the straight lines which are parallel to the X and Y axes, numbers are sequentially given to the divided segments from the central point, t corresponding to its number N is used as a parameter and it is assumed that

$$X_1(t) = \cos t$$
$$Y_1(t) = \sin t$$
$$X_2(t) = Y_2(t) = t$$
$$X(t) = X_1(t) \cdot X_2(t)$$

$Y(t) = Y_1(t) \cdot Y_2(t)$

then the values of $X_1(t)$, $Y_1(t)$, $X_2(t)$, and $Y_2(t)$ are recorded as the data using N as an address. With this method, a figure will not become notched since the outline of the pattern constituted by the horizontal and vertical lines becomes straight line in the position of $\beta = 0$.

The above-mentioned criterion functions comply with the previously mentioned expressions (7); however, it is of course possible to use other criterion functions which comply with other mathematical formula or the like corresponding to the required figures.

One embodiment of an apparatus which can be used to perform the present invention using the above-described criterion functions will be described hereinbelow with reference to Fig. 5.

In the drawing, a reference numeral 1 denotes a central-processing-unit (hereinafter, refered to as "CPU"); 2 is a read-only-memory (hereinafter, referred to as "ROM") in which programs and picture data or the like necessary for the display have been recorded; 3 is an random-access-memory (hereinbelow, referred to as an RAM) which is used at any time while in the operation; 4 is a spiral raster generator consisting of an ROM 5 for generating criterion functions, a criterion function registers 6, 7, 8, and 9, and multipliers 10 and 11; 12 is a magnification setting device; 13, 14, 15, and 16 are digital-to-analog converters; 17 and 18 are adders; 19 is a video

signal generator; 20 is a CRT display; 21 is a console for operation; and 22 is an encoder.

The CPU 1 takes in the necessary data from the ROM 2 and generates control signals necessary for display in response to an input from the console 21. These control signals consist of firstly a raster generation signal group which is sent to the spiral raster generator 4, magnification setting device 12, and digital-to-analog converters 15 and 16 respectively, and secondly a video control signal train which is sent to the video signal generator 19.

The previously mentioned criterion functions have been recorded in the ROM 5 acting as a criterion function generator, and its data is read out with a phase difference to be given from the CPU 1 for every function during the period when one spiral raster is being scanned.

The data to be read out for these criterion function registers 6 and 7 are respectively

$$X_1(t) = \cos t$$

$$X_2(t) = t$$

and the data to be read out for the registers 8 and 9 are respectively

$$Y_1(t) = \sin t$$

$$Y_2(t) = t$$

On the other hand, the multipliers 10 and 11 respectively perform the multiplications such as

$$X(t) = X_1(t) \cdot X_2(t) = t_1 \cdot \cos t_2$$

$$Y(t) = Y_1(t) \cdot Y_2(t) = t_1 \cdot \sin t_2$$

and then input the results to the digital-to-analog converters 13 and 14.

These inputs can be written respectively as follows:

$$X(t) = t \cdot \cos[\omega_0 \cdot t + \beta]$$
$$Y(t) = t \cdot \sin[\omega_0 \cdot t + \beta]$$

The D/A converters 13 and 14 convert these inputs into the analog values, the conversion magnifications are given by the CPU 1 and their outputs respectively corresponding to the sine wave portions of expressions (7), i.e.

$$F_0 \cdot t \cdot \cos[\omega_0 \cdot t + \beta]$$
$$F_0 \cdot t \cdot \sin[\omega_0 \cdot t + \beta]$$

In addition, the values of the central point (X_0, Y_0) of the raster are also simultaneously given from the CPU 1 and are converted into the analog values by the D/A converters 15 and 16. These values are then added to the outputs of the D/A converters 13 and 14 by the adders 17 and 18, so that the outputs shown in expressions (7) are obtained, i.e.

$$X(t) = X_0 + F_0 \cdot t \cdot \cos[\omega_0 \cdot t + \beta]$$
$$Y(t) = Y_0 + F_0 \cdot t \cdot \sin[\omega_0 \cdot t + \beta]$$

On the other hand, the video signal generator 19 generates a required video signal synchronously with the generation of the previously mentioned spiral raster.

The outputs of the adders 17 and 18 are added to the deflection coil of the CRT display 20 and the output of the video signal generator 19 is given to the control grid.

As the deflection coil circuit is a LR circuit, a phase difference appears between applied voltage across deflection coil and real current through said coil, therefore said video signals should not be synchronized with said applied voltage for deflection coil control but said current.

Said delay of phase is in proportion to frequency of deflection coil voltage waves, and in the case of constant tangental velocity scanning, said frequency is in inverse ratio to a radius of spiral scan line, therefore said difference in phase, in the end, is inversely proportional to radius of spiral scan line.

This shows a fact that length of spiral scan line corresponding said difference of phase angle is constant, namely, time lag between said deflection coil voltage and current is not dependent upon said frequency of deflection voltage, but constant.

Therefore, in the case that out put signals of the video signal generator 19 are synchronously generated with said applied voltage across the deflection coil, said out put signals should be given to the control grid of CRT 20 after a delay time which equal to said time lag, otherwise, the displayed pattern might be distorted.

Said delay of time might be given by a delay circuit which inserted between the video signal generator 19 and the control grid of CRT 20, or by delaying output signal of CPU 1 for controlling the video signal generator 19.

It can be easily understood that: the raster moves when the numeric values to be given from the CPU 1 to the D/A converters 15 and 16 change; the pattern is enlarged or reduced when the magnification to be given to the magnification setting device 12 changes; and the pattern rotates with the raster by changing the value of $(t_1 - t_2)$ mentioned before.

With respect to the criterion functions which are to be recorded in the ROM 5, other various known functions as well as the functions which have already been mentioned can be of course adoptable within the scope of the objects of the present invention.

Since the present invention is constituted as described above, according to the present invention, a number of colorful and brilliant patterns can be simultaneously generated on the CRT display and these patterns can be freely moved, enlarged, reduced, and rotated by a simple circuit constitution.

Furthermore, the constitution of the present invention is not limited to the above-described embodiments. Namely, the gist of the present invention is that: the horizontal and vertical deflections are controlled by the sine waves; the amplitudes, frequencies and phase difference of them are controlled; thereby producing a spiral raster

and then arbitrarily moving, enlarging, reducing, and rotating it. Therefore, it is possible to freely change the technical means with respect to the method of generating sine waves, controlling method, shapes of rasters, etc. whithin the range of the objects of the present invention.

CLAIMS:

1. A method of displaying a picture by a change in luminance of light spot to be generated on a picture screen by an electron beam which scans on the screen along a spiral raster which is to be drawn on the screen, comprising the steps of:

determining a plurality of starting points on said screen;

determining a sequence of said plurality of starting points;

determining a shape, phase, linear density, and scanning speed of the spiral raster which diverges from or converges toward each of said starting point;

determining pattern data for specifying a luminance of each point of each of said spiral rasters, thereby determining the pattern to be displayed;

sequentially scanning the spiral rasters corresponding to the respective starting points by the electron beam in accordance with said determined sequence, and controlling an intensity of said electron beam in response to said pattern data, thereby generating the pattern corresponding to each of said starting points; and

controlling a shape, phase and scanning speed of said spiral raster corresponding to each of said starting points, thereby enlarging, reducing, modifying, or rotating the patterns displayed on the screen.

2. A method of displaying a picture by a change in luminance of light spot to be generated on a picture screen by an electron beam which scans on the screen along a spiral raster which is to be drawn on the screen, comprising the steps of:

generating an X-axial deflection control signal X(t) which is determined by an expression

$$X(t) = X_0 + F_1(t) \cdot \sin[\omega_1(t) \cdot t + \beta_1]$$

wherein X_0 and β_1 are constants, t is a time $(0 \leqq t \leqq t_0)$, and $F_1(t)$ and $\omega_1(t)$ are functions of a time;

generating a Y-axial deflection control signal Y(t) which is determined by an expression

$$Y(t) = Y_0 + F_2(t) \cdot \sin[\omega_2(t) \cdot t + \beta_2]$$

wherein Y_0 and β_2 are constants, t is a time $(0 \leqq t \leqq t_0)$, and $F_2(t)$ and $\omega_2(t)$ are functions of a time;

controlling the electron beam in response to said X- and Y-axial deflection control signals X(t) and Y(t), thereby scanning the spiral raster;

generating a video signal synchronously with said spiral raster scanning, thereby generating a pattern on said spiral raster; and

controlling said constants X_0, Y_0, β_1, β_2, and t_0, and values of constants which are included in said $F_1(t)$, $F_2(t)$, $\omega_1(t)$, and $\omega_2(t)$, thereby moving, rotating, reducing or enlarging, and modifying the pattern generated on said spiral raster.

3. A picture displaying method according to claim 2, wherein

$$\omega_1(t) = \omega_2(t) = \omega_0$$

$$\beta_1 = \beta_2 + \frac{\pi}{2}$$

$$\beta_2 = \beta$$

$$F_1(t) = F_2(t) = F_0 \cdot t$$

and wherein the pattern generated on the spiral raster is moved, rotated, reduced or enlarged, and modified by controlling values of

β, ω_0 and F_0.

4. A picture displaying method according to claim 2, wherein

$$\beta_1 = \beta_2 + \frac{\pi}{2}$$

$$\beta_2 = \beta$$

and

$$\omega_1(t) = \omega_2(t) = \omega(t)$$

$$F_1(t) = F_2(t) = F(t)$$

$$V = \sqrt{\left(\frac{dX}{dt}\right)^2 + \left(\frac{dY}{dt}\right)^2}$$

$$= \text{constant}$$

so that said functions $F_1(t)$, $F_2(t)$, $\omega_1(t)$, and $\omega_2(t)$ are determined, and wherein the pattern generated on the spiral raster is moved, rotated, reduced or enlarged, and modified by controlling constants which are included in (t) and F(t) and a value of β.

5. A method of displaying a picture by a change in luminance of light spot to be generated on a picture screen by an electron beam which scans on the screen along a spiral raster which is to be drawn on the screen, comprising the steps of:

generating an X-axial deflection control signal X(t) which is determined by an expression

$$X(t) = X_0 + F_1(t) \cdot \sin[\omega_1(t) \cdot (t_0 - t) + \beta_1]$$

wherein X_0 and β_1 are constants, t is a time ($0 \leq t \leq t_0$), and $F_1(t)$ and $\omega_1(t)$ ate functions of a time;

generating a Y-axial deflection control signal Y(t) which is determined by an expression

$$Y(t) = Y_0 + F_2(t) \cdot \sin[\omega_2(t) \cdot (t_0 - t) + \beta_2]$$

wherein Y_0 and β_2 are consistants, t is a time ($0 \leqq t \leqq t_0$), and F_2 (t) and ω_2 (t) are functions of a time;

controlling the electron beam in response to said X- and Y-axial deflection control signals X(t) and Y(t), thereby scanning the spiral raster;

generating a video signal synchronously with said spiral raster scanning, thereby generating a pattern on said spiral raster; and

controlling said constants X_0, Y_0, β_1, β_2, and t_0, and values of constants which are included in said $F_1(t)$, $F_2(t)$, $\omega_1(t)$, and $\omega_2(t)$, thereby moving, rotating, reducing or enlarging, and modifying the pattern generated on said spiral raster.

6. A picture displaying method according to claim 5, wherein

$$\omega_1(t) = \omega_2(t) = \omega_0$$

$$\beta_1 = \beta_2 + \frac{\pi}{2}$$

$$\beta_2 = \beta$$

$$F_1(t) = F_2(t) = F_0 \cdot t$$

and wherein the pattern generated on the spiral raster is moved, rotated, reduced or enlarged, and modified by controlling values of β, ω_0 and F_0.

7. A picture displaying method according to claim 5, wherein

$$\beta_1 = \beta_2 + \frac{\pi}{2}$$

$$\beta_2 = \beta$$

and

$$\omega_1(t) = \omega_2(t) = \omega(t)$$

$$F_1(t) = F_2(t) = F(t)$$

$$V = \sqrt{\left(\frac{dX}{dt}\right)^2 + \left(\frac{dY}{dt}\right)^2} = \text{constant}$$

so that said functions $F_1(t)$, $F_2(t)$, $\omega_1(t)$, and $\omega_2(t)$ are determined, and wherein the pattern generated on the spiral raster is moved, rotated, reduced or enlarged, and modified by controlling constants which are included in $\omega(t)$ and $F(t)$ and a value of β.

8. An apparatus for displaying a picture by a change in luminance of light spot to be generated on a picture screen by an electron beam which scans on the screen along a spiral raster which is to be drawn on the screen, comprising:

means for generating an X-axial deflection control signal $X(t)$ which is determined by an expression

$$X(t) = X_0 + F_1(t) \cdot \sin[\omega_1(t) \cdot t + \beta_1]$$

or

$$X(t) = X_0 + F_1(t) \cdot \sin[\omega_1(t) \cdot (t_0 - t) + \beta_1]$$

wherein X_0 and β_1 are constants, t is a time $(0 \leqq t \leqq t_0)$, and $F_1(t)$ and $\omega_1(t)$ are functions of a time;

means for generating a Y-axial deflection control signal $Y(t)$ which is determined by an expression

$$Y(t) = Y_0 + F_2(t) \cdot \sin[\omega_2(t) \cdot t + \beta_2]$$

or

$$Y(t) = Y_0 + F_2(t) \cdot \sin[\omega_2(t) \cdot (t_0 - t) + \beta_2]$$

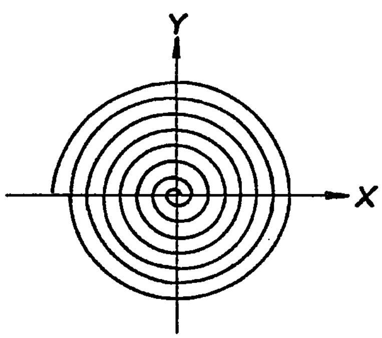
wherein Y_0 and β_2 are constants, t is a time $(0 \leqq t \leqq t_0)$, and $F_2(t)$ and $\omega_2(t)$ are functions of a time;

means for controlling the electron control signals $X(t)$ and $Y(t)$, thereby scanning the spiral raster;

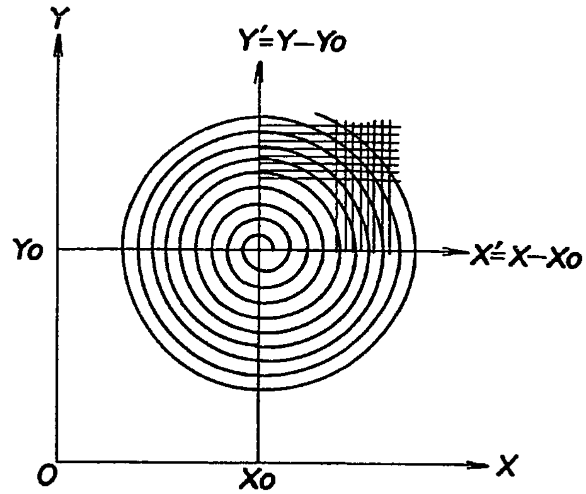
means for generating a video signal synchronously with said spiral raster scanning, thereby generating a pattern on said spiral raster; and

means for controlling said constants X_0, Y_0, β_1, β_2, and t_0, and values of constants which are included in said $F_1(t)$, $F_2(t)$, $\omega_1(t)$, and $\omega_2(t)$, thereby moving, rotating, reducing or enlarging, and modifying the pattern generated on said spiral raster.

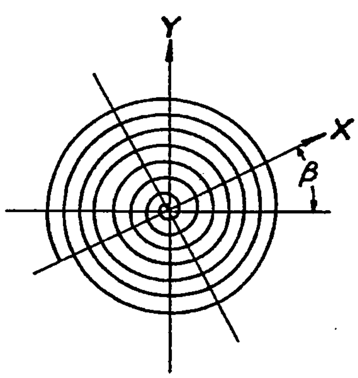
F I G. 1



F I G. 3



F I G. 2



F I G. 4

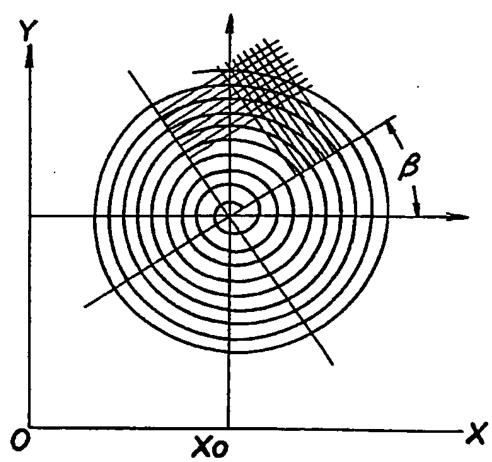
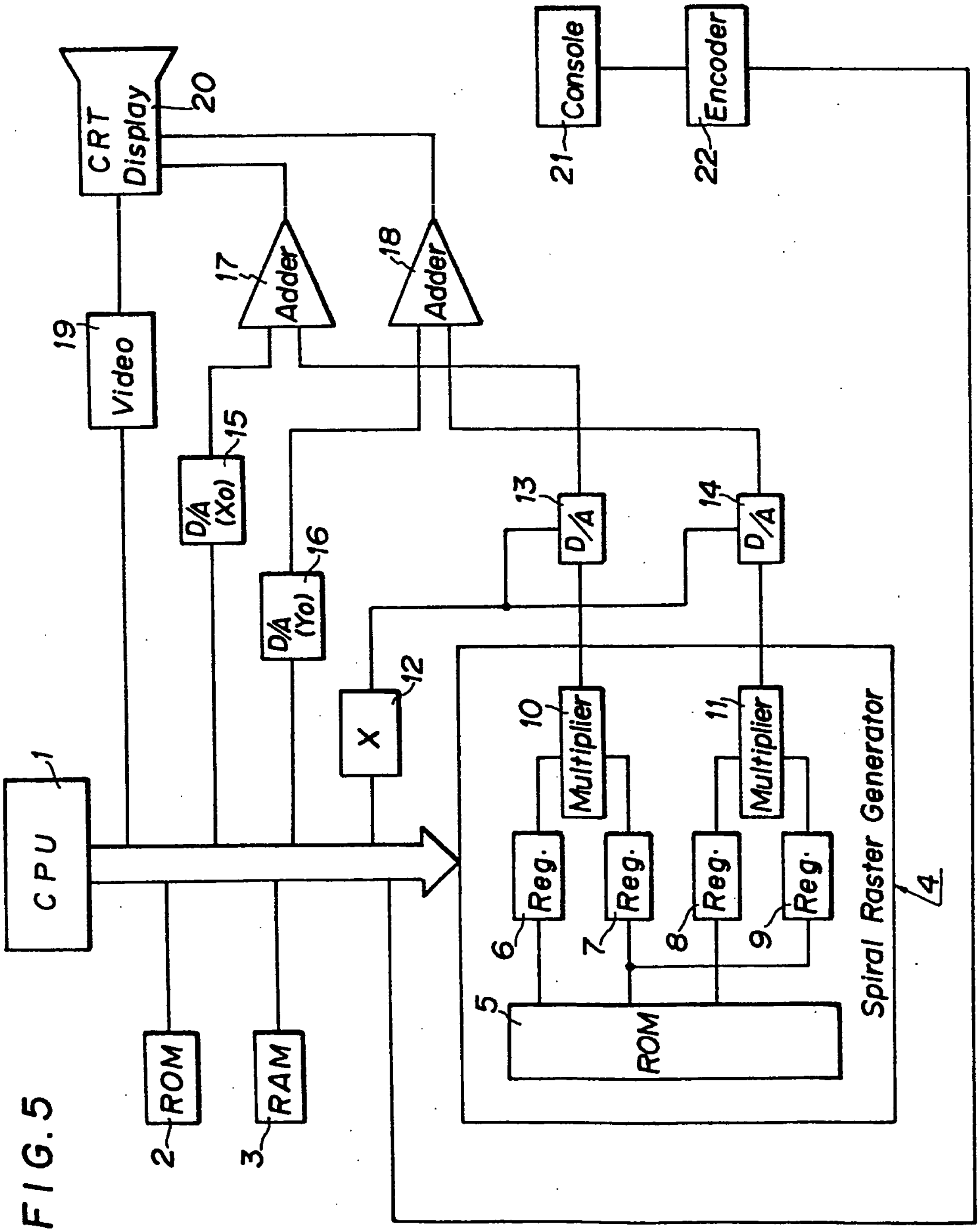


FIG.5



CPU
1
ROM
2
RAM
3
Video
19
CRT Display
20
Adder
17
Adder
18
D/A (Xo)
15
D/A (Yo)
16
D/A
13
D/A
14
X
12
Multiplier
10
Multiplier
11
Reg.
6
Reg.
7
Reg.
8
Reg.
9
ROM
5
Spiral Raster Generator
4
Console
21
Encoder
22